BASIC SCIENCE SERIES

14

SPACE AND MAN

REVISED EDITION

CONTENTS

INTRODUCTION

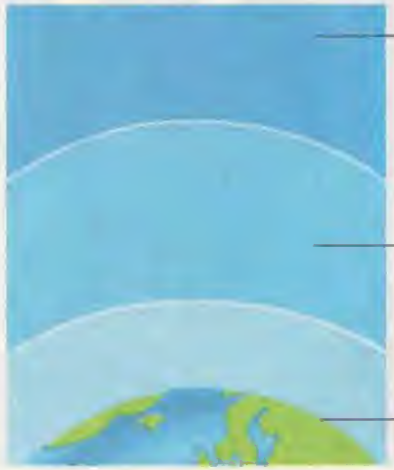
When you look up into the sky on a clear night, you will see the moon and the stars. Since ancient times men have been curious to know more about the moon, the stars and other bodies in the sky. They invented telescopes to get a closer look at them and discovered that there are many suns, moons and planets in the sky. They became eager to explore the mysterious sky.

Man has throughout the ages studied the skies.

On October 4, 1957, the **Space Age** began when the first man-made **satellite** (you will learn about this later) was sent into space to circle round the Earth. Today, scientists are able to land men on the moon. More space explorations will be made in the future. In this book we shall learn about Man and his explorations in space.

WHAT IS SPACE?

The Earth is surrounded by a layer of air, called the **atmosphere**. The atmosphere determines the weather on Earth. The atmosphere close to the Earth's surface is thick. It gradually becomes thinner, as we move further away from the Earth. The region beyond the Earth's atmosphere which contains the rest of the Universe is known as **space**.



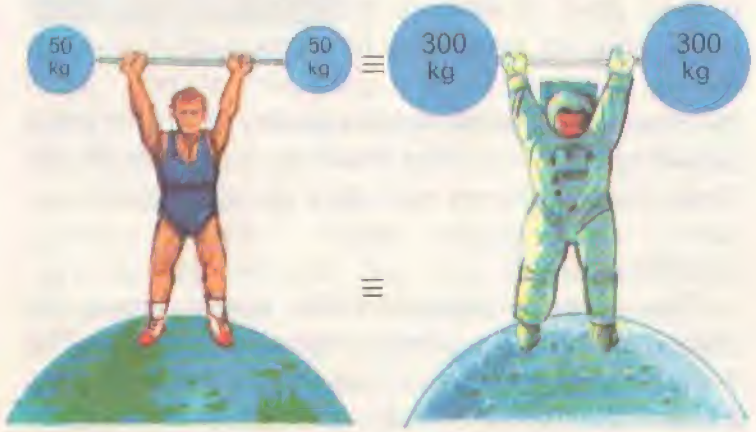
Space lies beyond earth's atmosphere.

WHAT IS THE FORCE OF GRAVITY?

If you throw a ball up, it will come down again. What makes it come down? The ball comes down because it is pulled or attracted towards the Earth. The Earth exerts a force of attraction on all objects. Objects that are nearer to the Earth are attracted to it with a greater force than those that are further away. This force of attraction is known as the **force of gravity**. The gravitational force acting on an object at the Earth's surface is called the **weight** of the object.

All the heavenly bodies in space like the moons, the planets and the stars also exert an attractive force on objects. The bigger and heavier a body is, the greater is its force of gravity. Thus, since the moon is a smaller body

You can lift things six times heavier on the moon.



than the Earth, the force it exerts on an object at its surface is less than that exerted by the Earth on the same object on the Earth's surface. In fact, the moon's gravitational force is only one-sixth that of the Earth's. This means that an object weighing 120 kilograms on Earth will only weigh 20 kilograms on the moon. Therefore on the moon you could lift weights which are six times heavier than the heaviest weight that you can lift on Earth.

The Earth's gravitational force or pull keeps us and everything else on Earth from floating away to space. To get out into space and travel to the moon or other planets we have to overcome the Earth's gravitational pull.

ENTRY INTO SPACE

How can we overcome Earth's gravitational pull? Scientists have been working on this for a long time. It is only recently that they have been able to build machines powerful enough to get out of Earth's gravitational pull. Such machines are called **space rockets**. Their great speed and power help them to escape from the Earth's gravitational pull and go into space.

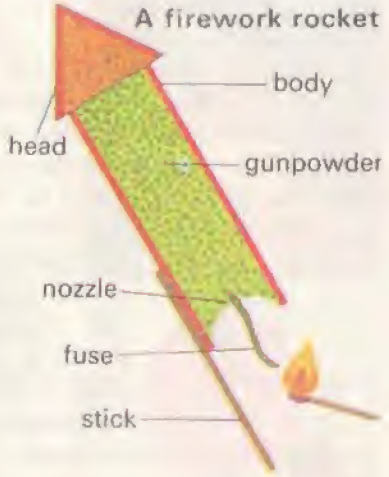
ROCKETS

The powerful space rocket works along the same lines as a simple firework rocket. The firework rocket has a cylindrical body and a conical head. The body is packed with **gun-**

powder which is the fuel. It is a mixture of chemicals that will burn rapidly to form hot gases.

At the base or foot of the rocket there is an opening or **nozzle**. A fuse hangs out like a tail from the nozzle. A long stick attached along the body serves to direct the rocket before the fuse is lighted.

A firework display

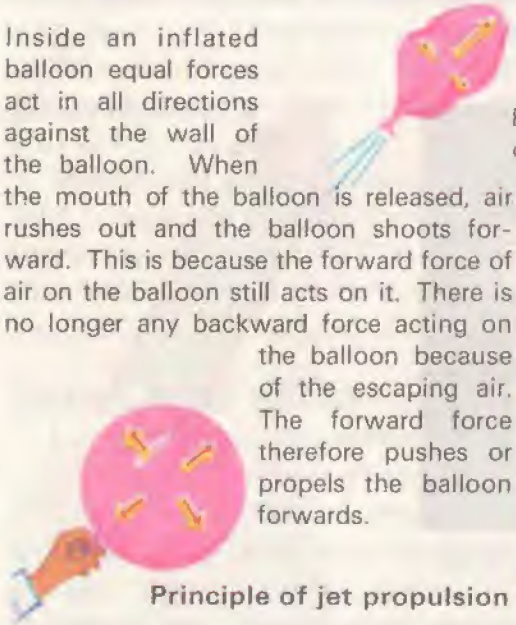


When the gunpowder burns, hot gases or **exhaust** gases rush out of the nozzle. The hot gases continue to rush out as long as the gunpowder burns. When these gases shoot downwards through the nozzle the rocket is pushed upwards. This is called **jet propulsion**. The simple experiment, shown in the picture, will help you to understand jet propulsion.

Space rockets work in the same way as the

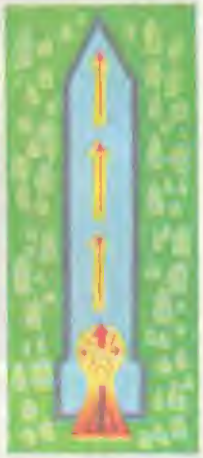
firework rockets. However space rockets may weigh several thousand tonnes and stand more than ninety metres high. They are so big because they have to carry a large amount of fuel and the necessary amount of oxygen for burning the fuel.

Inside an inflated balloon equal forces act in all directions against the wall of the balloon. When the mouth of the balloon is released, air rushes out and the balloon shoots forward. This is because the forward force of air on the balloon still acts on it. There is no longer any backward force acting on the balloon because of the escaping air. The forward force therefore pushes or propels the balloon forwards.



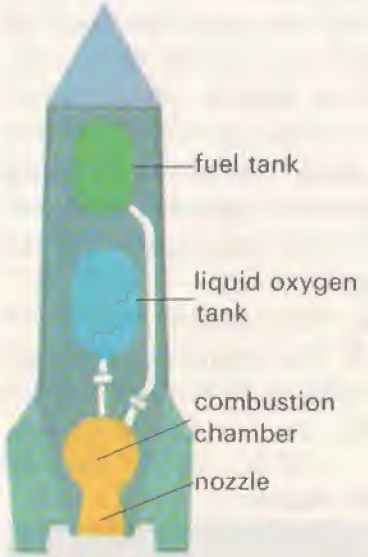
Principle of jet propulsion

Rockets too work on this principle.



The oxygen contained in the rocket is either in the liquid or the solid form. The common fuels used by rockets are kerosene and alcohol.

When a rocket is fired or **launched** into space a lot of heat and hot gases are released through the nozzle. The flames and smoke from the nozzle rise up high above the ground and the sound is deafening.



A section of a space rocket

Courtesy of United States Information Service, Singapore

A rocket blast-off

We know that a rocket has to reach a great speed to escape from Earth's gravitational pull. The speed required is about 40,200 kilometres per hour (25,000 miles per hour). This speed is known as **escape speed** or **escape velocity**. To reach such a speed a lot of fuel must be burned.

The space rocket is used to launch a **spacecraft** into space. This spacecraft may be unmanned or manned.

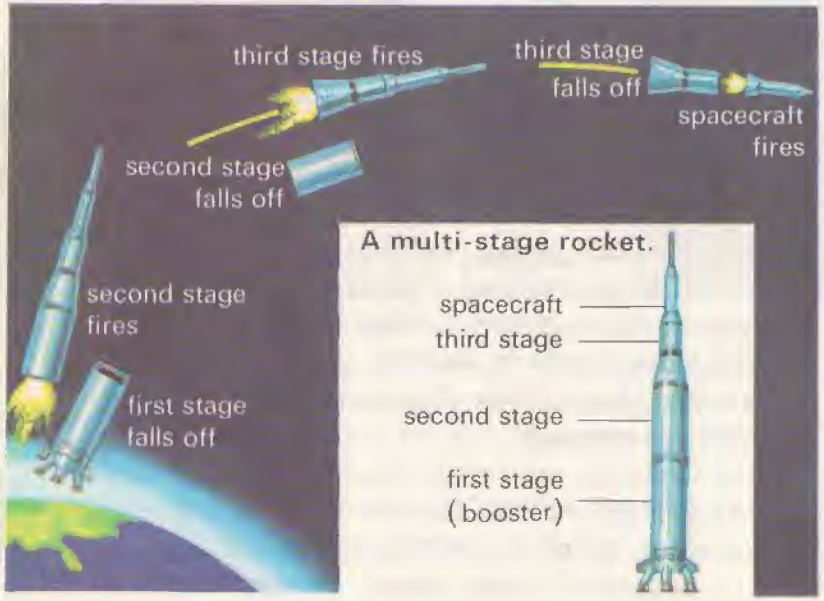
MULTI-STAGE ROCKETS

A single rocket is not powerful enough to send a spacecraft into space. This is because

the amount of fuel a single rocket can carry, is not enough to supply the necessary amount of power. To get enough fuel and power to last till the spacecraft gets out of Earth's gravitational pull, a number of rockets are needed. These rockets are linked one atop the other, looking much like a giant lighthouse. Together they form a **multi-stage rocket**. The spacecraft lies at the top of the multi-stage rocket.

The first stage of a multi-stage rocket is called the **booster**. It is the biggest as it has to lift the whole rocket system from the ground. The booster helps to lift the rocket over the

Entry into space.



thick region of the atmosphere. When the fuel of the booster is used up it separates from the rest of the rocket and drops to Earth. When this happens the second stage fires and propels the rocket further towards space. After some time the second stage, having used up its fuel, just like the booster, separates and falls off. The third stage, to which the spacecraft is attached then fires. It carries the spacecraft into space. When the third stage uses up its fuel, it too falls off. The spacecraft is then left to travel to its destination on its own power.

RETURN TO EARTH

Spacecraft can be launched into space with the help of multi-stage rockets. But before manned spacecraft could be sent to space, the problem of getting the spacecraft safely back to Earth had to be solved.

There are many dangers to overcome when a spacecraft returns to earth. The main one is speed. When a spacecraft returns to Earth it will be travelling at a great speed. In order to land on Earth, the returning spacecraft must be slowed down. This is done by firing special rockets called **retro-rockets**. The **capsule** or the part of the spacecraft which contains the spacemen separates from the rest of the spacecraft. The capsule re-enters the Earth's atmosphere and may fire several retro-rockets in order to slow down.

The heat shield protects the spacecraft.

The parachutes of a spacecraft

The atmosphere also acts as a kind of brake and slows down the capsule. However a lot of heat is given out because of the great speed at which the capsule pushes through the atmosphere. To prevent the capsule from burning up, it is protected by a **heat shield**. Parachutes are also used to slow down the capsule further so that it can land safely.

Scientists have been able to send men into space, and bring them back to Earth. They could only do this after studying about space and the bodies in it.

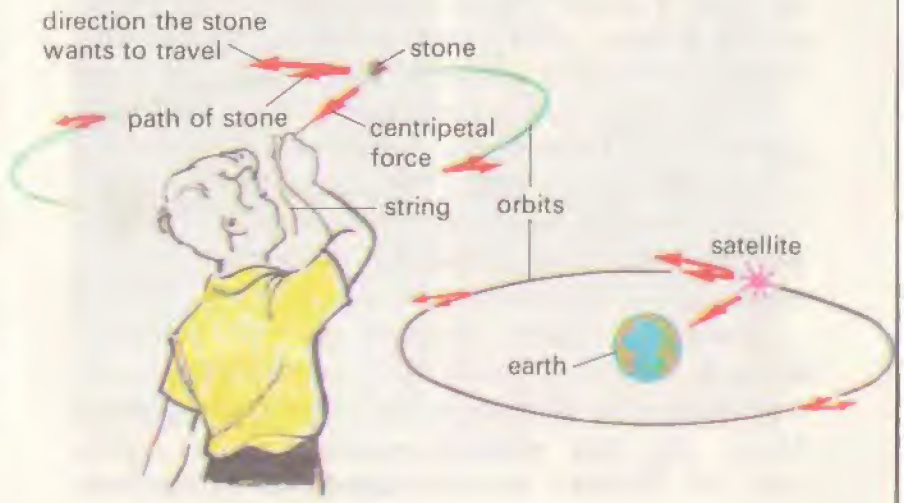
SATELLITES

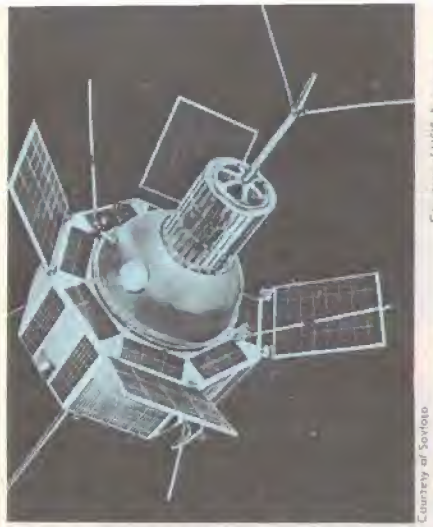
The body that is nearest to the Earth is the moon. It circles the Earth and is therefore known as a satellite of the Earth. Earth has one such satellite while some of the other planets have more. These satellites are called **natural satellites**. Man-made spacecraft which circle the Earth are called **artificial satellites**.

Natural as well as artificial satellites circle the planets in a definite path or **orbit**. Why do satellites stay in orbit? Why don't they shoot off into outer space?

This behaviour of satellites can be explained by doing a simple experiment. Tie a stone to a piece of string and whirl it around your head. If you let your end of the string go, the stone will not keep moving in a circle. It will fly away in a straight line.

An experiment to show why satellites stay in orbit.





Courtesy of Sovfoto

A scientific satellite.

Courtesy of USIS Singapore

A weather satellite.

Moving things always travel in straight lines at the same speed unless they are acted on by force. When the stone is whirling around your head, the string keeps pulling the stone inward so that it travels in a circle rather than in a straight line. This force keeping the stone moving in a circle is called the centripetal force.

A satellite stays in orbit because the planet's gravitational force keeps pulling it into a circle, just as the string keeps the stone moving in a circle. If there were no gravitational force, the satellite would not circle the planet but would move off into outer space.

There are many artificial satellites orbiting around the Earth. Some artificial satellites have been sent up to orbit the moon and even the planet Mars. The first artificial satellite to orbit Earth was the Russian satellite, **Sputnik I**. The first

American satellite was called **Explorer I**.

Artificial satellites can be used for various purposes. The following are some different types of satellites.

1. *Weather satellites:* These satellites help in forecasting the weather. They contain special cameras which can photograph the formation of clouds all over the Earth from space. Scientists are able to forecast the weather by studying these photographs.

2. *Communication satellites:* These satellites orbit at a much higher level than weather satellites. They contain special instruments which can pass on or relay radio and television programmes or telephone messages from one station to another.

Courtesy of United States Information Service, Singapore

A communication satellite relays messages from one station to another.

3. *Scientific satellites:* These satellites carry scientific instruments which can gather various information about space. Such satellites have been able to send back information about **radiation**, **meteors** and **magnetism** in space.

4. *Probes:* These are unmanned spacecrafts which scientists send to the moon and the planets. They send back information and close-up photographs of these places.

The information sent back by artificial satellites helped scientists to send manned spacecraft safely into space. This created a new and exciting group of explorers — the **spacemen**.

THE SPACEMEN

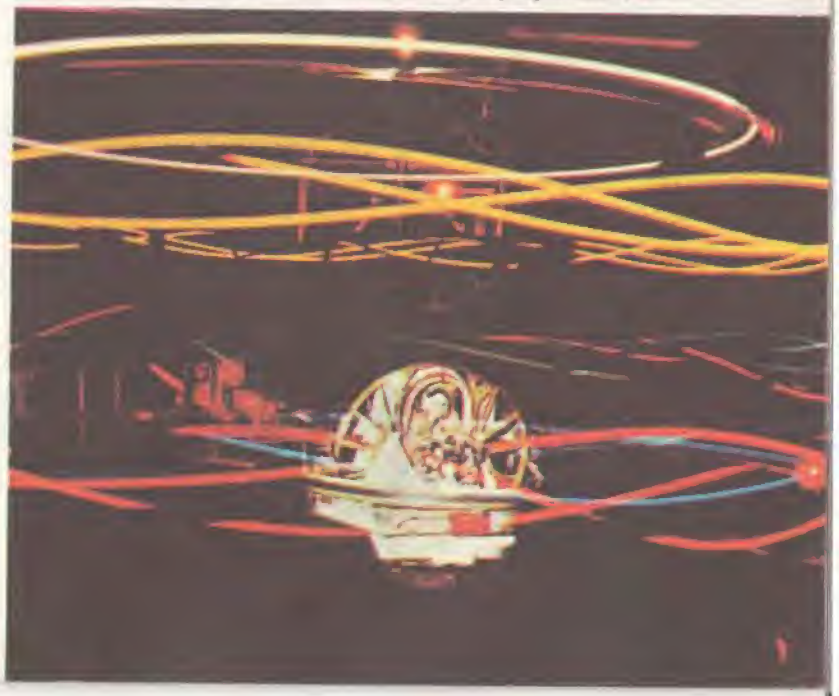
American spacemen are called **astronauts**, while Russian spacemen are known as **cosmonauts**. Spacemen have to be specially trained for travelling in space. They should be in very good mental and physical health. Most of them are experienced pilots of very fast aeroplanes.

All spacemen have to do various space exercises before travelling to space. They have to be fit enough to bear the great pressures they will feel at launching and landing. When travelling in space or orbiting round a planet, the feeling of weight which the force of gravity produces is gone. This condition is known as **weightlessness**. Spacemen have to become used to the weightless conditions in space and learn how to walk, eat, drink and sleep in a condition of

weightlessness. They train for their space travels in dummy spacecraft which are like the actual spacecraft. The dummy spacecraft can be made to do many things that an actual spacecraft does in space. They can be made to whirl quickly in all directions. This enables the spacemen inside to get used to the tumbling that they will experience in space. Spacemen also have to know all about the various parts of their spacecraft. They should be able to repair any part that is damaged while travelling.

When Man goes into space he must take air, food and water. He must also be able to get rid of stale air and waste matter. Food is prepared

An astronaut trains in a dummy spacecraft.



in a paste form and kept in tubes. The spaceman 'eats' his food by squeezing the food paste into his mouth. Waste is stored in containers and got rid of when the spacecraft reaches Earth. These problems have been solved for short space trips, but not for long trips.

Spacemen have to wear an outfit called a **spacesuit**. A spacesuit is heavy and has several layers. The layer next to the spaceman's skin contains water. It acts as a cooler. This layer prevents him from getting too warm under all the other layers. The next layer is airtight. It is supplied with air for the spacemen to breathe. It also protects him from the extreme heat and cold of space. Another layer lies over the air-tight layer. This layer is known as a pressure skin. It keeps the pressure of the air in the spacesuit the same as that of Earth's atmosphere.

An astronaut with his spacesuit.

The outer layer of the spacesuit is padded and protects the inner layers.

The spacesuit is coated with a shiny substance. This substance helps to reflect the heat and harmful rays of the sun. The spacesuit is not complete without the space helmet. This looks very much like an inverted goldfish bowl. The surface of the helmet is also coated with a shiny substance. It contains earphones and micro-phones for the spaceman to communicate with others.

A cord from the spacesuit is connected to the **life-support unit** which supplies fresh air to the spacesuit. This unit also supplies air to the spacecraft, and removes stale air and moisture.

Several spacemen have carried out successful space explorations. Space explorations planned by scientists are known as **space projects**.

EVENTS OF THE SPACE AGE

The Space Age began when the Russians carried out their first successful space project. This was the launching of the first satellite, Sputnik I, into space, on October 4, 1957. Soon several other satellites were sent into space and various space explorations were made. We shall look at some of the important space projects and also at some famous spacemen of the Space Age.

1. On 3rd Nov. 1957, the Russians sent up **Sputnik II**. It carried the first living thing,

Courtesy of USIS, Singapore

A. Shepard

Yuri Gagarin

V. Tereshkova

a dog named **Laika**, into space. However Laika died in space.

2. On April 12, 1961, the first man was launched into space and returned safely to Earth. His name was **Yuri Gagarin**, a Russian. He orbited the Earth for 108 minutes. The first American who was sent into space was **Alan B. Shepard**, while the first woman sent into space was **Valentina Tereshkova**, a Russian.

Courtesy of USIS, Singapore

Edward White makes a "space walk". What would happen to him if the cord should snap?

3. The first man to step out of his spacecraft and "walk" in space was Alexei A. Leonov, a Russian cosmonaut. Edward White was the first American astronaut to make a "space walk".

4. American astronauts **Frank Borman, James Lovell** and **William Anders** made the first orbit round the moon.

Neil Armstrong

Edwin Aldrin

Courtesy of United States Information Service, Singapore

5. On July 16, 1969, the **Apollo 11** was launched. It carried the American astronauts **Neil Armstrong, Edwin Aldrin** and **Michael Collins** to the moon. Four days later on July 20, 1969, Neil Armstrong became the first man to land on the moon. He was followed later by Edwin Aldrin while Collins orbited around the moon. The moon became the first body in space on which Man set foot.

6. On September 12, 1970, **Luna 16**, the Russian unmanned spacecraft landed on the moon. It scooped up moon dust and returned to Earth on September, 24, 1970.

7. On June 6, 1971 three Russian cosmonauts — **Georgi Dobrovolsky, Vladdislav Volkov** and **Viktor Patsayev** — took off on **Soyuz 11** to space. They docked their spacecraft by the side of the big unmanned craft **Salyut**. The Salyut had been launched to space several months earlier. It acted like a space station. The three cosmonauts spent three weeks working in the Salyut. Unfortunately on their return journey they died. Their death was due to a fault in their spacecraft, Soyuz 11. However these cosmonauts proved that man could work safely in space for long periods.

8. About a month after this sad event, the **Apollo 15** was launched. It carried astronauts **David Scott**, **James Irwin** and **Alfred Worden**. Scott and Irwin landed on the moon,

James Irwin with the "moon buggy."

while Worden remained orbiting around the moon. A vehicle called the "moon buggy" was taken along on this trip. It looked like a jeep. The astronauts drove the "moon buggy" on the moon.

9. On November 14, 1971, the American planetary probe, **Mariner-9** went into orbit around Mars. This probe took about five and a half months to make the journey from Earth to Mars. It became the first spacecraft to orbit another planet.

10. The Russians went a step further in planetary explorations on November, 30, 1971. The space probe Mars-2 while orbiting Mars, released the Russian flag in a capsule on to the planet. This was the first man-made object that landed there.

THE FIRST JOURNEY TO THE MOON

The most exciting of the space events was Man's first journey to the moon and back. To know how this was accomplished, let us study the structure of Apollo 11 and follow it on its historic journey to the moon.

The Apollo 11 had four main sections. They were (i) the **launch vehicle**, named the **Saturn V**, which was a three-stage rocket, (ii) the **service module**, (iii) the **command module** and (iv) the **lunar module**.

The service module contained the rocket engines and fuel supplies for use in space.

The command module, known as the

Columbia, was the place where the Apollo 11 crew stayed during the launching. It looked like the crew apartment of an airliner. It had windows and also instruments to control the spacecraft.

The lunar module, named the **Eagle**, was like a ferry. It was specially built to take the astronauts from the command module to the moon's surface and back.

The spot from where a spacecraft is launched is called the **launching pad**. The launching of Apollo 11 was at Cape Kennedy, United States of America. The lift-off or **blast-off** of Apollo 11 took place on July 16, 1969. At noon on the same day the Apollo 11 was moving out of the earth's gravitational pull. By that time the booster and the second stage of

Cape Kennedy

The Apollo 11 blasts off

Courtesy of United States Information Service, Singapore

1. The command and service modules shoot out and 2. make a U-turn. 3. The command and lunar modules dock and 4. separate from the third stage.

Courtesy of USIS, Singapore

The command module docks with the lunar module.

the launch vehicle had burned out and dropped to Earth. A much lighter third stage helped the Apollo 11 to continue its journey to the moon.

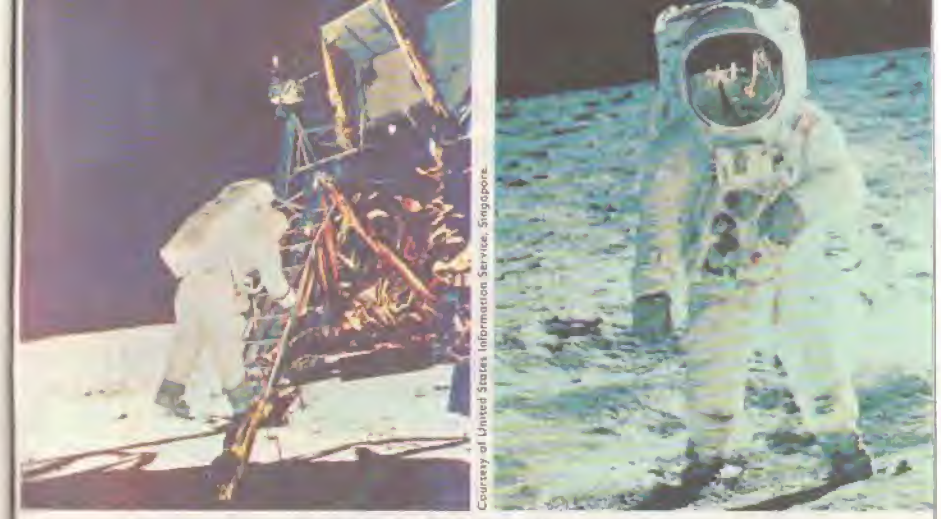
Attached to the third stage were the lunar module, the service module and the command module in that order. With this arrangement of the modules, the astronauts in the command module had no way of entering the lunar module. When the time came for the astronauts to enter the lunar module, Neil Armstrong used explosives to open the four doors or panels of the structure or **adapter**, which housed the lunar module. The command and service modules pulled away at the same time. The

lunar module however, remained attached to the third stage, with its nose facing outwards.

To link the command and lunar modules a special move had to be made. The command module to which was attached the service module made a roundabout or U-turn and approached the lunar module. It then faced nose to nose with the lunar module. They then docked and moved away from the third stage which was of no use anymore to the astronauts. The nose sections of the command and lunar modules formed a tunnel. The astronauts Armstrong and Aldrin crawled into the lunar module through this tunnel.

The spacecraft, now consisting of the lunar, command and service modules (attached in that order) continued the journey to the moon. On July 19, the spacecraft began to orbit around the moon. On July 20, the lunar module carrying Armstrong and Aldrin, separated from the command module and prepared to land on the moon. It fired retro-rockets to decrease its speed and then landed on the moon. Collins who remained in the command module, continued to orbit around the moon.

A few hours after the lunar module landed on the moon, Neil Armstrong stepped on to the surface of the moon. He was followed by Aldrin. The two astronauts took photographs of the moon's surface, planted the American flag and also collected moon soil. They left a few scientific instruments on the moon. These instruments were



Edwin Aldrin on the moon

put there to help scientists record information about the moon.

On July 21, the lunar module blasted off from the moon. It rejoined the command module which was orbiting round the moon. After docking with the command module, Armstrong and Aldrin returned to the command module. The lunar module was separated from the command module and discarded as there was no more use for it. On July 22, the astronauts got away from the moon's gravitational pull and journeyed back to Earth. On July 24, just before entering Earth's atmosphere the service module was discarded. The command module then fired its retro-rockets and positioned its blunt base to face the atmosphere. The base which had to push through the atmosphere was attached to the protective heat-shield.

Courtesy of United States Information Service, Singapore.

Recovery of the Apollo 11 astronauts

As the command module travelled through the Earth's atmosphere its speed decreased. This was because the atmosphere acted as a brake. The heat of the module however increased as it pushed through the atmosphere but the heat-shield protected the astronauts. At about three kilometres from the Earth's surface the three giant parachutes of the module were released. The command module then safely dropped or made a **splashdown** in the Pacific Ocean.

The astronauts were then taken on board the vessel, the U.S.S. Hornet. They were kept in isolation in the Hornet for several days and examined by doctors before being taken to Houston, U.S.A. The astronauts became heroes of U.S.A. and the world. The historic journey to and from the moon was successfully completed.

SPACE TRAVEL

The journey to the moon has been the first step towards future explorations in space. The

distance between the moon and Earth is very short indeed when compared with the distances between Earth and the other planets. Mars, the nearest planet to Earth is millions of miles away! Travelling to the planets or **interplanetary** travels will be Man's next aim. Such travels will be more challenging than the trip to the moon and certainly more adventurous.

Recently, two American unmanned spacecraft, Vikings 1 and 2, landed on Mars in an attempt to discover whether that planet has any life on it. So far the presence of life on Mars has neither been confirmed nor ruled out. Russian space-probes have discovered that the surface of Venus is so hot that it is almost certain that there is no life there. Also the atmosphere of Venus is extremely dense and the pressure is

Building a space station.

nearly a hundred times greater than the pressure of the Earth's atmosphere.

Scientists believe that in the future, space stations can be built in space. These stations can act as stop-over points in space. Spacecraft can refuel at these stations and replenish their supply of air, food and water. These stations may be designed like the one shown in the picture on page 31.

In the near future scientists may build **nuclear rockets**. Such rockets will solve the problem of frequent refuelling as they need only a small amount of fuel to last for very long journeys.

Spaceships of the future will be bigger and faster. They will be able to carry passengers for trips to the moon or planets.

Man may in the future find planets which have the same conditions as those we have on Earth, and make them his home. However such a possibility is still in the distant future. Meanwhile Man should realise that the Earth will be his only home for a long time and begin to cherish and care for it.